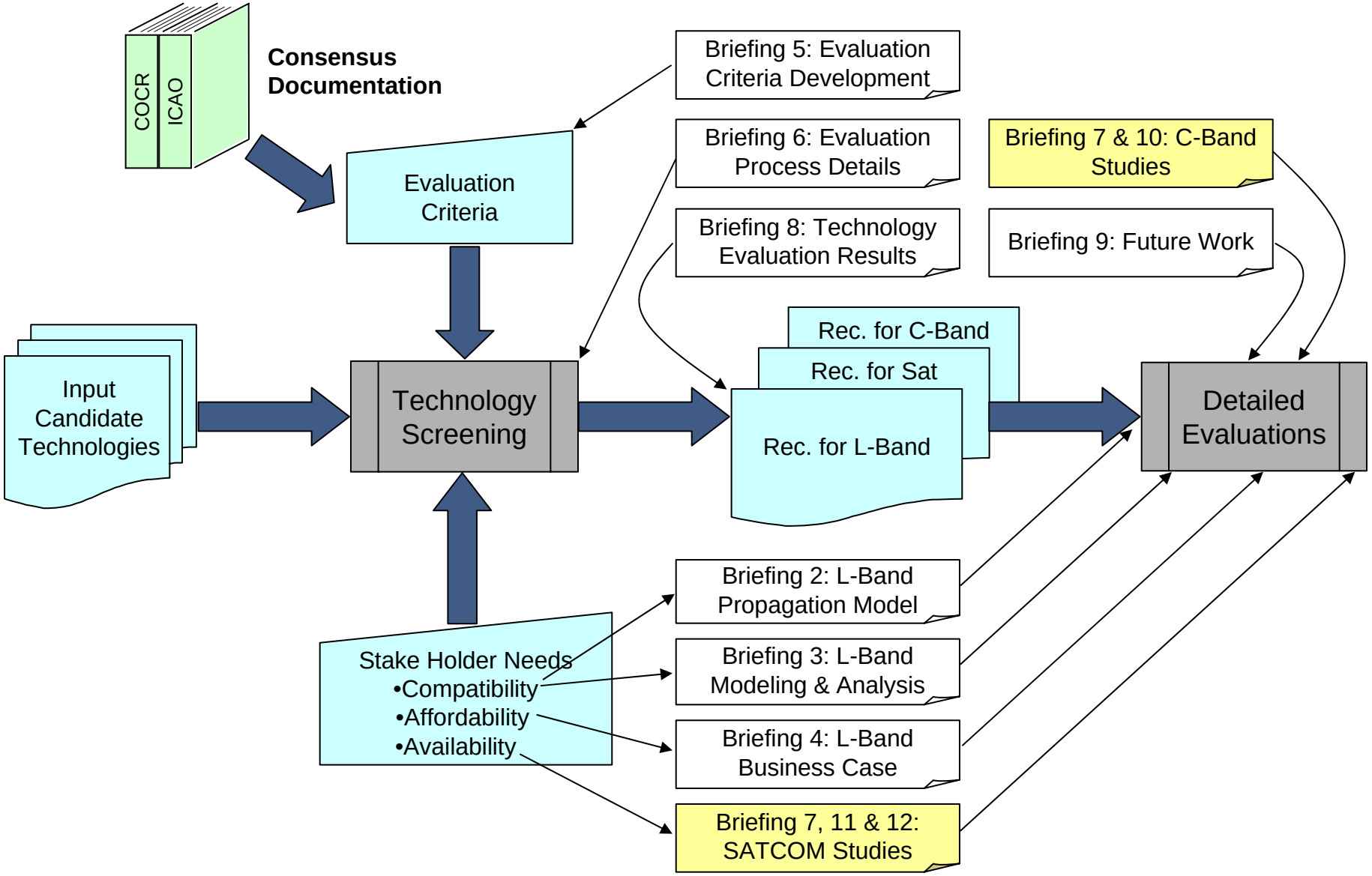
Briefing #7 - Overview of SATCOM and C-Band Results

Future Communications Study

Phase II End of Task Briefing

June 21, 2006

Structure and Content of the Presentations



Briefing Outline

- Purpose
- Overview of SATCOM Analysis Task Results
  - SATCOM Availability Analysis
  - SATCOM COCR Service Provisioning Assessment
- Overview of C-Band Analysis Task Results

Purpose

- To provide a brief overview and summary of the SATCOM and C-Band analysis task results, which will be presented in greater detail during tomorrow's briefings
- Intended for those who are unable to attend tomorrow

Overview of SATCOM Analysis Results

Task Activity Descriptions: SATCOM Task

- The purpose of this task was to assess the viability of using existing commercial satellite systems with AMS(R)S frequency allocations to provide the communications services that are detailed in the COCR
- The satellite studies task (Briefings 11 & 12) primarily supported the detailed investigation of candidate technologies for the Future Radio System
  - Evaluate availability of SATCOM technology candidates Inmarsat SBB and Iridium (Briefings 11 and 12)
  - Determine if SATCOM technology candidate architectures can meet COCR requirements (Briefing 12)
  - Compare/contrast the performance of current SATCOM data service offerings with AMS(R)S allocations with existing/representative terrestrial data services (Briefings 11 and 12)

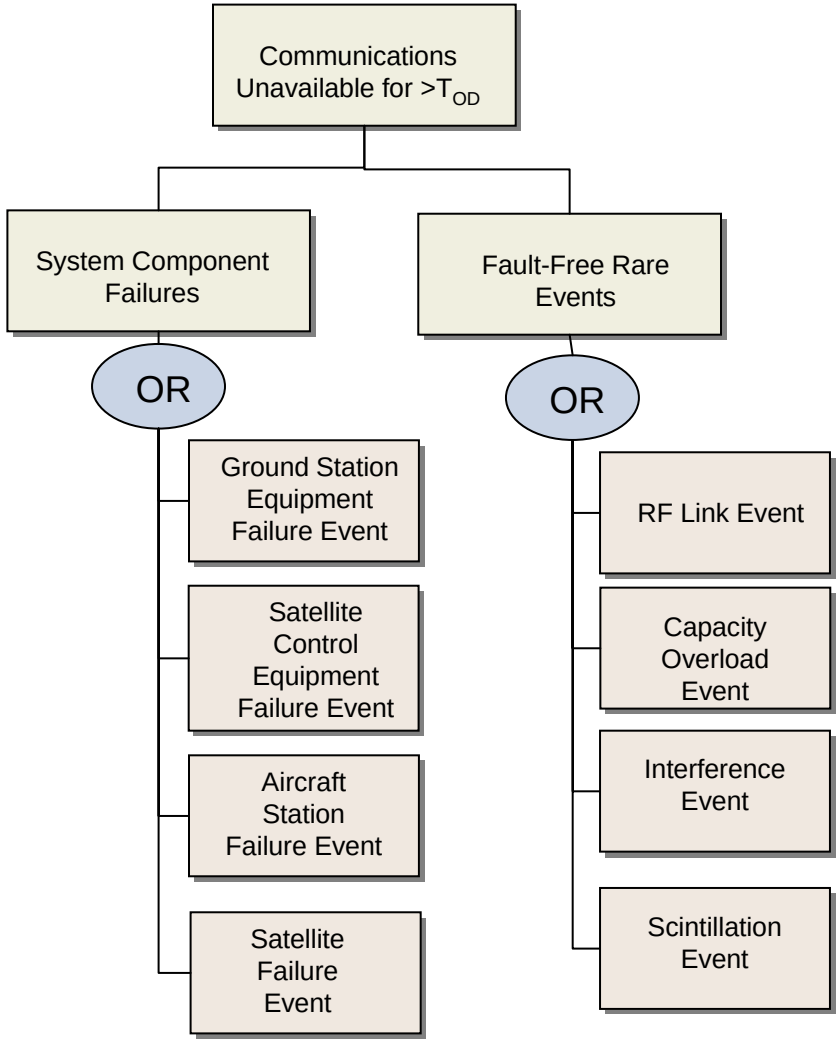
SATCOM Availability Analysis - Briefing 11

SATCOM Availability Analysis Overview

- Two satellite service architectures with AMS(R)S frequency allocations were selected for consideration in this availability analysis
  - Inmarsat-4 SwiftBroadband (SBB) service
  - Iridium communication service
- Calculated availability of these architectures was contrasted with the calculated availability of a generic VHF terrestrial communication architecture
  - Data communications architecture based on existing infrastructure

SATCOM Availability Analysis Approach

- Utilized SATCOM availability analysis model described in RTCA DO-270
  - Defines availability fault-tree to permit individual characterization and evaluation of multiple availability elements
  - Organized into two major categories
    - System Component Failures
    - Fault-Free Rare Events
  - Model is useful for comparing architectures and was used for this study



SATCOM Availability Analysis Summary Results

- Summary –
  - Limiting factors for availability are as follows:
    - SATCOM systems:
      - Satellite equipment failures and RF link effects
      - Capacity Overload (Iridium)
      - Interference (Iridium)
    - VHF Terrestrial communication systems:
      - RF link events

	System Component Failures				Fault-Free Rare Events			
	Ground Station	Control Station	Aircraft Station	Satellite	RF Link	Capacity Overload	Interference	Scintillation
Inmarsat	***~ 1***	***~ 1***	***~ 1***	***0.9999***	***0.95***	***~ 1***	***~ 1***	***~ 1***
Iridium	***0.99997***	***~ 1***	***~ 1***	***0.99***	***0.995***	***- [1]***	***0.996***	***~ 1***
VHF Terrestrial	***0.99999***	N/A	***~ 1***	N/A	***0.999***	***- [2]***	***~ 1***	N/A

Notes:

1. Iridium Capacity Overload availability of AES to SATCOM traffic is essentially one (1) (for both ATS only and ATS & AOC). No steady-state can be achieved for SATCOM to AES traffic.
2. Terrestrial Capacity Overload availability is for VHF-Band reference architecture business case; for L-Band Terrestrial Capacity Overload availability would be essentially one (1).

SATCOM COCR Service Provisioning Assessment - Briefing 12

SATCOM COCR Service Provisioning Assessment Objectives

- Examine the provisioning of COCR services over Inmarsat SBB and Iridium with respect to availability performance
- Provide a high-level analysis of hybrid SATCOM architectures

COCR Service Provisioning Assessment Summary and Conclusions

- Analysis Summary

Architecture Name	Functional Capability	Performance Capability	Cost	Technical Risk	Benefit
A. Dual GEO/LEO Satellite Architecture	MEETS	PARTIALLY MEETS	HIGH	HIGH	LOW
B. Geographic-based allocation of services across terrestrial/satellite architecture	MEETS	PARTIALLY MEETS	MODERATE	LOW	MODERATE
C. Service-based allocation of services across terrestrial/satellite architecture	MEETS	PARTIALLY MEETS	HIGH	MODERATE	MODERATE

- Conclusions
  - There is a potential role for hybrid satellite architectures for aeronautical mobile communications
    - Role is not obvious, but an architecture that may satisfy multiple roles (e.g. provide capacity and emergency backup, such as provided by architectures B and C or a combination of the two) may be desirable
  - No one architecture is a stand-out
    - Architectures B and C (geographic-based and service-based allocation of services to terrestrial/SATCOM systems) appear to have greater potential than a SATCOM/SATCOM architecture (architecture A)

Overview of C-Band Analysis Results – Briefing 10

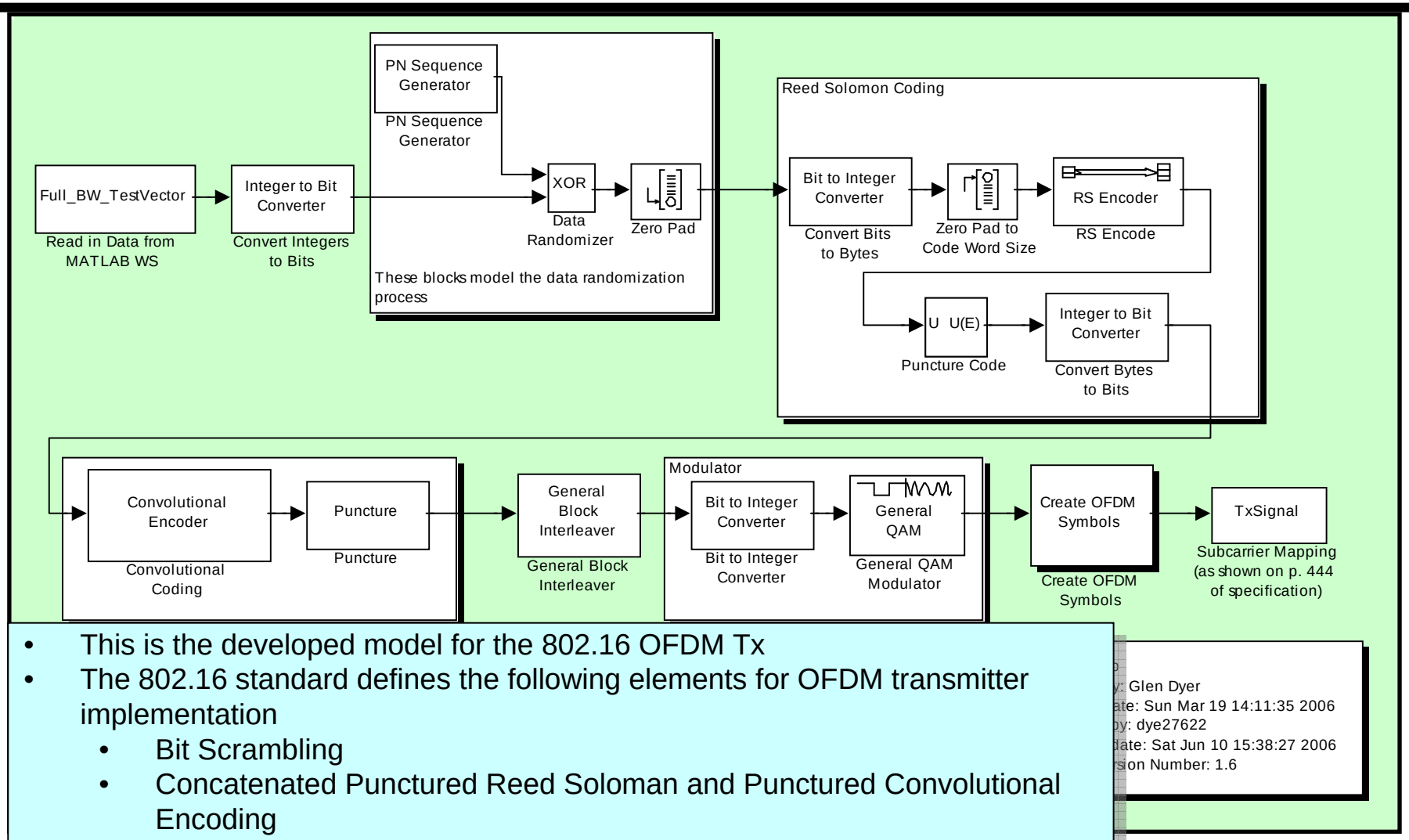
Task Activity Descriptions: C-Band Activities

- The purposes of this activity were to model the C-Band surface (airport) propagation environment including the effects of multipath fading, and to assess the performance of a commercial C-Band technology in that environment.
- Work Activities
  - 802.16e was selected for analysis because it was recommended in the first phase of the FCS Technology Assessment activities
  - This task leveraged the C-Band propagation measurements and channel modeling performed at airports by Ohio University
  - It developed a detailed simulation of 802.16e, implemented the Ohio University airport channel models, and assessed system performance

802.16 Overview

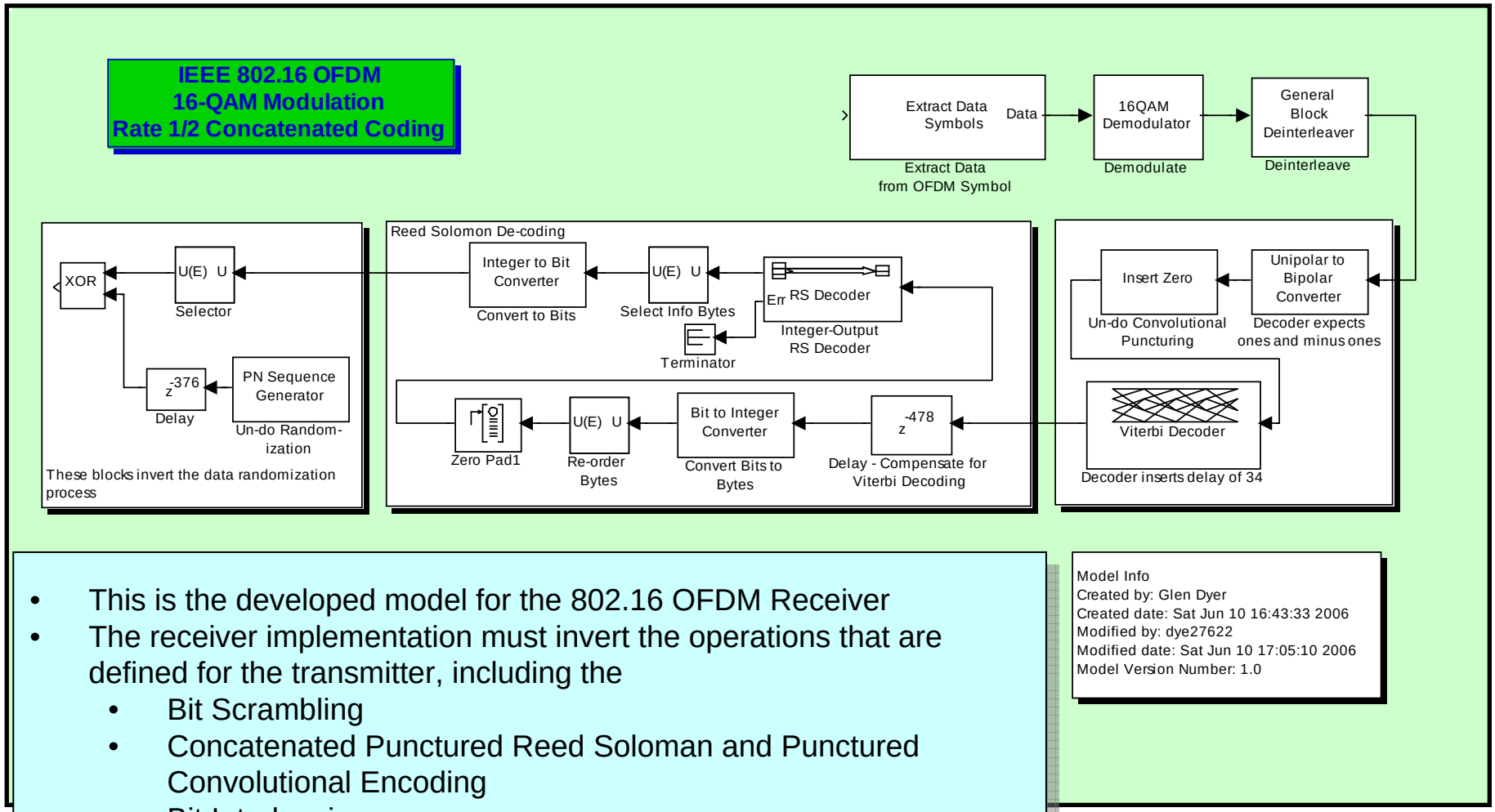
- 802.16 is the IEEE developed standard for Wireless Metropolitan Area Networks (MAN)
  - Originally defined as fixed access only (mobility added with 802.16e)
  - Provides very efficient use of spectrum
  - Provides high bandwidth, with hundreds of users per channel
  - Flexible QoS offerings
    - Unsolicited Grant Services for constant bit-rate service flows (SFs)
    - Real-time Polling Services for real time Variable Bit Rate SFs
    - Non-real-time Polling Services
    - Best Effort
  - Wide range of applicable frequencies (up to 66 GHz)
  - High data rates for uplink and downlink
  - Supports multiple physical interfaces

802.16e Transmitter
(as Modeled in Simulink)



- This is the developed model for the 802.16 OFDM Tx
- The 802.16 standard defines the following elements for OFDM transmitter implementation
  - Bit Scrambling
  - Concatenated Punctured Reed Soloman and Punctured Convolutional Encoding
  - Bit Interleaving
  - Adaptive Modulation
  - OFDM Symbol Creation

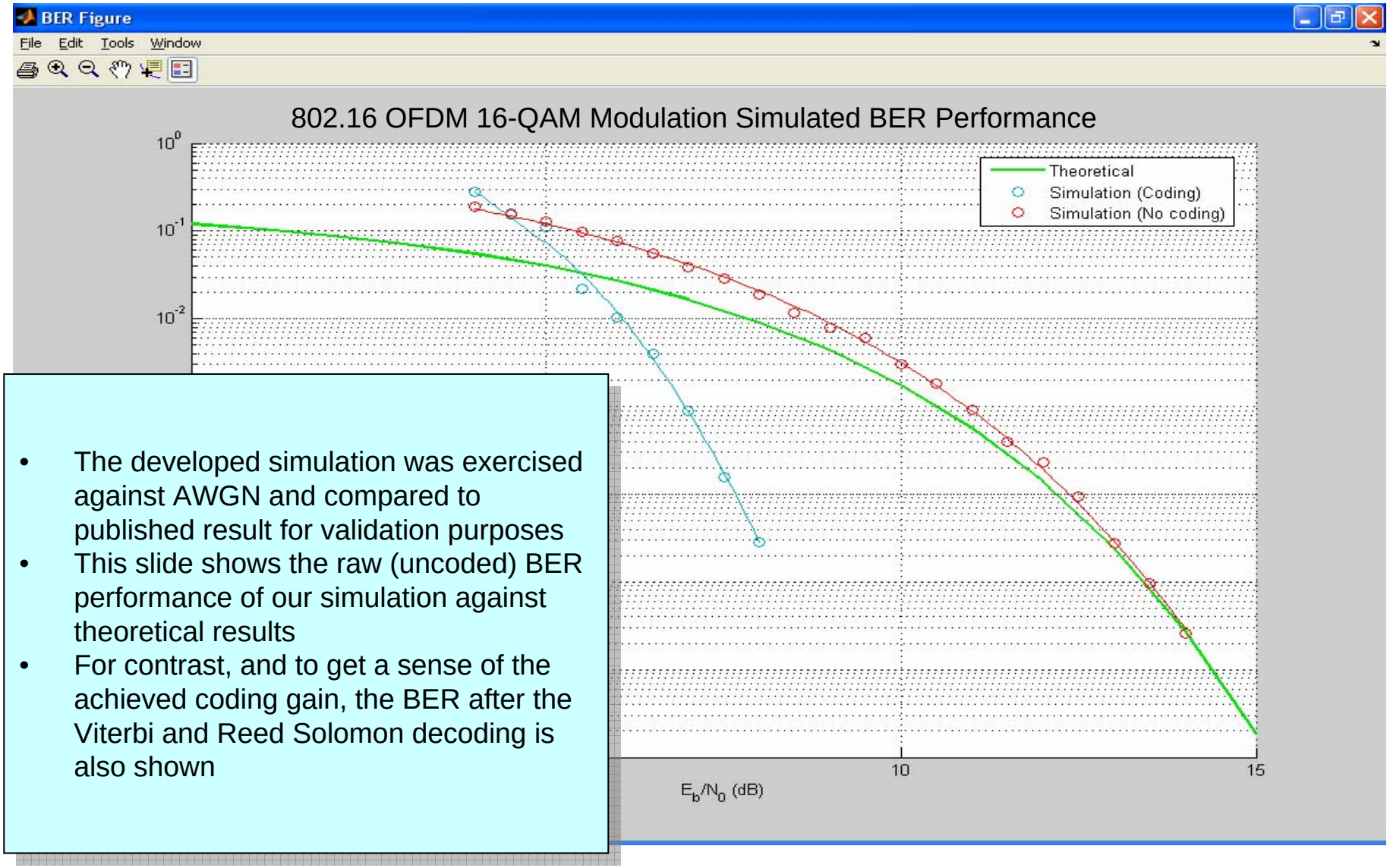
802.16e Receiver
(as Modeled in Simulink)



- This is the developed model for the 802.16 OFDM Receiver
- The receiver implementation must invert the operations that are defined for the transmitter, including the
  - Bit Scrambling
  - Concatenated Punctured Reed Soloman and Punctured Convolutional Encoding
  - Bit Interleaving
  - Adaptive Modulation
  - OFDM Symbol Creation

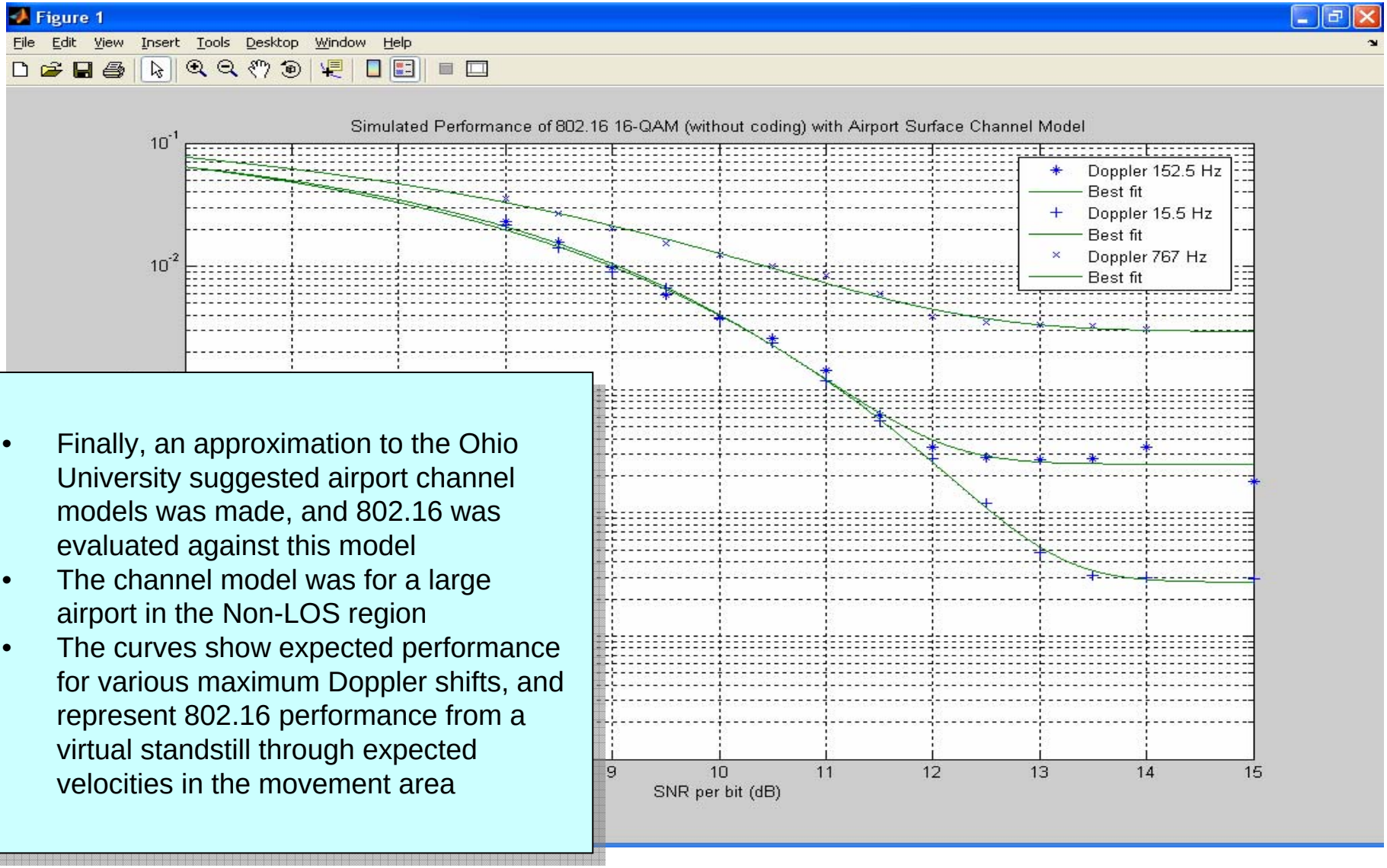
Model Info
Created by: Glen Dyer
Created date: Sat Jun 10 16:43:33 2006
Modified by: dye27622
Modified date: Sat Jun 10 17:05:10 2006
Model Version Number: 1.0

Validating Simulation Results



- The developed simulation was exercised against AWGN and compared to published result for validation purposes
- This slide shows the raw (uncoded) BER performance of our simulation against theoretical results
- For contrast, and to get a sense of the achieved coding gain, the BER after the Viterbi and Reed Solomon decoding is also shown

Simulated 802.16 16-QAM Performance



- Finally, an approximation to the Ohio University suggested airport channel models was made, and 802.16 was evaluated against this model
- The channel model was for a large airport in the Non-LOS region
- The curves show expected performance for various maximum Doppler shifts, and represent 802.16 performance from a virtual standstill through expected velocities in the movement area